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(54) **Display device**

(57) A display device for a clock comprises a stator (13) and a rotor (14) overlying the stator (13), and a motor (16) for producing relative movement between the rotor and stator. The stator (13) has a first display pattern of light producing regions (22,23) and the rotor (14) has a second display pattern of light transmitting regions (27,28). On the stator (13) eleven sectors (22) are painted in a first colour and eleven interleaved sectors (23) are painted in a complementary colour. The rotor (14) has twelve sectors (27) of material transparent to the light of the first colour and twelve sectors (28) transparent to light of the second colour. The sectors of light transmitting material (27,28) are interleaved with one another around the disc and alternate with sectors of opaque material (29). When the stator is observed through the rotor during rotation a moving resultant pattern (21B) is seen which rotates at twelve times the speed of rotation of the rotor (14), and has an improved resolution over known arrangements.

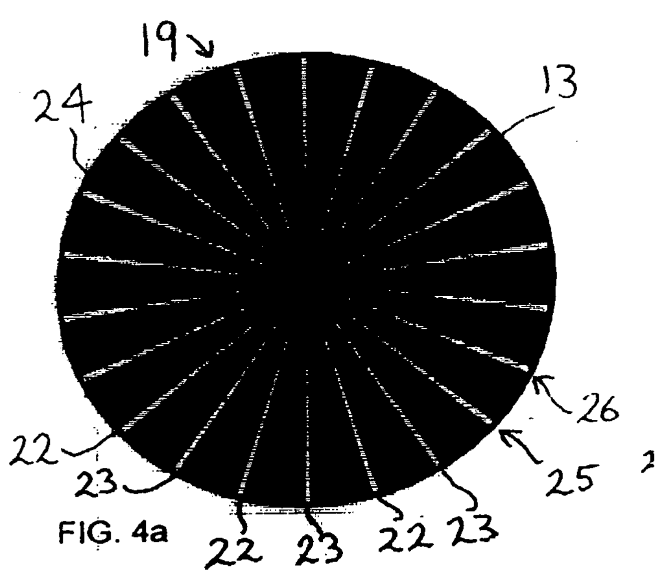

FIG. 4a

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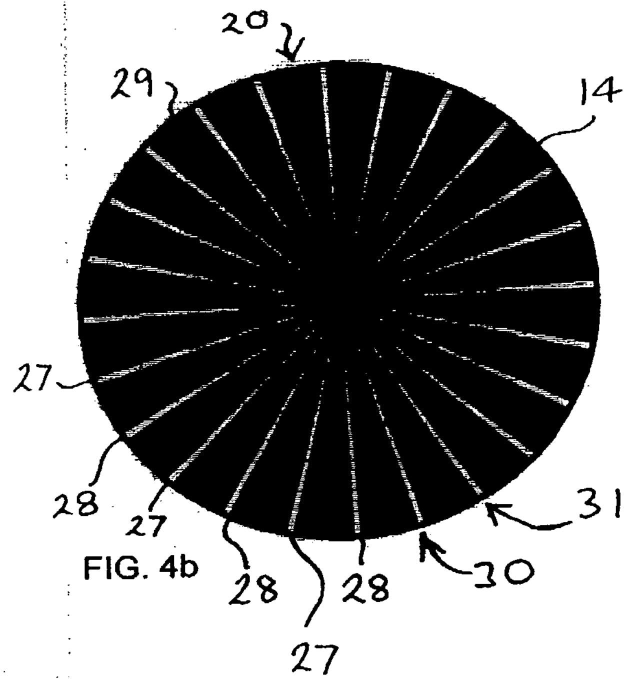


FIG. 4b

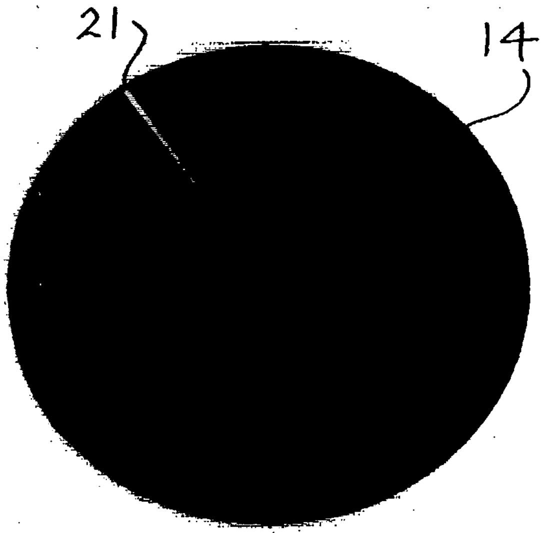


FIG. 4c

Description

[0001] The present invention relates to a display device, particularly but not exclusively a display device for a watch or clock.

[0002] In a conventional clock of the analogue kind the time is read by the position of an hour hand and a minute hand, and sometimes also a second hand. In a conventional clock, gears drive two or three shafts at different speeds, and a hand attached to each shaft indicates its position. The hour hand rotates once every twelve hours, the minute hand rotates twelve times every twelve hours, and the second hand, if present, rotates seven hundred and twenty times every twelve hours.

[0003] It is known to produce an optical effect by having a stationary disc and a rotary disc positioned in register with the stationary disc and being rotated relative thereto, there being on the stator a pattern of alternating light reflecting and light non-reflecting regions, and on the rotor a related pattern of alternating light transmitting and non-transmitting regions, such that when the rotor is rotated and the stator is viewed through the light transmitting regions of the rotor, a resultant moving pattern is established which rotates around the axis of the rotor. Typically there will be provided on the stator a pattern of alternating light and dark coloured regions each in the form of a sector of the disc, and on the rotor a pattern of alternating light transmitting and opaque regions, again each being in the form of a sector of the disc. It may be arranged that the stator has N-1 dark and N-1 white sectors, and the rotor has N transparent and N opaque sectors where N is any whole number. When the rotor is rotated, the resultant pattern will rotate N times faster than the speed of rotation of the rotor.

[0004] It is known to use this visual effect to produce an indication of time in a clock. Relevant prior art includes GB-A-2,206,712; US-A-4,274,154; and DE-A-3503672. In GB-A-2,206,712 there is disclosed an analog clock which has a stationary disc and a rotating disc, portions of which are said to be graduated such that they form a rotary vernier. A fixed mark is displayed on the rotating disc, which is rotated one revolution every twelve hours, the fixed mark constituting an hour hand. The graduations of the vernier are arranged and illuminated such that as the fixed mark on the disc rotates one revolution every twelve hours and indicates the time in hours, the vernier graduations enable minutes to be read. The stationary disc has eleven markings and the rotary disc has twelve markings (N = 12), the superimposition of the two giving a visual display which rotates once every hour.

[0005] Such an arrangement gives rise to the following problem. If the alternating light and dark regions of the stator are of equal width, and the opaque and transparent regions of the rotor are of equal width, then the resultant pattern consists of N-1 (eg. 11) light regions of varying thickness, so that it is difficult to determine visually precisely where the resultant pattern is pointing at any one time. Precision may be increased by making the light regions of the stator and the transparent regions of the rotor narrower, as described in DE-3503672-A1, or by tapering these regions, as described in GB-A-2,206,712, but it will always be the case:

(a) that at certain times in the motion the resultant pattern appears as more than one, separate light region (or, if the light and transparent regions are made narrower still, that the resultant pattern at certain times disappears altogether); and

(b) that the resultant pattern can only be visible at all in N-1 (eg. 11) widely spaced angular positions, and can never be seen in other positions, so that any more accurate indication of rotation can only come from visual interpolation.

[0006] This problem is particularly acute with low values of N, such as the N=12 value required to provide the minute-hand display of a clock or watch.

[0007] It is one object of the invention to provide a display which, when used to display the time on a clock or watch, gives a clearer indication of the position of a time indicator on the clock, although it is to be appreciated that the invention finds application in many other forms of display device.

[0008] According to the present invention there is provided a display device comprising: display means for displaying a first display pattern in combination with a second display pattern; and means for producing relative movement between the first and second display patterns; the first and second display patterns each having features which recur regularly along the direction of relative movement between the two display patterns at repetition rates which are different on the two display patterns; the display patterns being related in such a manner as to give rise to a moving resultant pattern which is the result of the interaction of the first and second display patterns during the said relative movement, the resultant pattern moving at a speed greater than the said relative movement between the first and second display patterns; characterised in that each display pattern is composed of more than one component pattern; each component pattern having a feature which recurs regularly along the direction of relative motion between the display patterns; one of the component patterns on the first display pattern being associated with one of the component patterns on the second display pattern, and another of the component patterns on the first display pattern being associated with another of the component patterns on the second pattern, in such a manner that the visual effect of viewing in combination two associated component patterns is different from the visual effect of viewing in combination two non-associated component patterns; and it being arranged that for each pair of associated component patterns, the repetition rate for a component pattern of the first pattern is different from

the repetition rate for an associated component pattern of the second pattern.

[0009] The composition of each display pattern from more than one component pattern allows a clearer display, and increases the resolution which is available in defining the moving resultant pattern. For example where the display device is a rotary device, and the moving resultant pattern is used to indicate the passage of time by a minute hand, the provision of, for example, two component patterns on each of the display patterns can be arranged to provide twenty two distinct positions of the minute hand rather than the eleven distinct positions which have been provided previously in prior art arrangements. However it will be appreciated that the invention is not limited to this example, and that the resolution may be further increased for example by increasing the number of component patterns.

[0010] Preferably the composition of each of the display patterns from its component patterns is such that at every location of the display pattern, the pattern emits, reflects or transmits substantially whatever light would be emitted, reflected, or transmitted at that location by any of the component patterns on its own; and the component patterns are such that the resultant pattern that results from the interaction of the display patterns is substantially the composition of the resultant patterns that would have resulted from the interaction of pairs of associated component patterns taken in turn.

[0011] Conveniently the features of the invention in preferred forms can be represented symbolically as follows. Denoting the first display pattern by A and the second display pattern by B, it is convenient to denote the resultant pattern that results from the interaction of A and B by A·B. The precise meaning of the interaction operator "·" depends on the way in which the interaction between the display patterns is arranged in a particular embodiment of the invention.

[0012] Continuing to denote the first display pattern by A and the second display pattern by B, the composition of each of the patterns from its component patterns may be expressed as $A=A_1+A_2+...+A_n$, and $B=B_1+B_2+...+B_n$, where $A_1, A_2 .... A_n$ denotes n component patterns, n being a whole number indicating the number of component patterns which are present. The operation "+" of composition of a display pattern is defined as set out above, namely that at every location of the display pattern, the pattern emits, reflects or transmits substantially whatever light would be emitted, reflected or transmitted at that location by any of the component patterns on its own. (It should be emphasised that the composition of the component patterns A_1, A_2, ... A_n to make A and the component patterns B_1, B_2, ... B_n to make B is not a process that occurs in the operation of the invention but is a calculation that is made in order to design appropriate first and second display patterns A and B for use in the invention.)

[0013] It follows from the definitions given above that the resultant visible pattern A·B is defined by $A \cdot B = (A_1+A_2+...+A_n)\cdot(B_1+B_2+...+B_n)$, which, from the definition of "·" and "+", may be expanded algebraically to

$$\begin{aligned} A\cdot B= {} & A_1\cdot B_1+A_1\cdot B_2+...+A_1\cdot B_n \\ & +A_2\cdot B_1+A_2\cdot B_2+...+A_2\cdot B_n \\ & +... \\ & +A_n\cdot B_1+A_n\cdot B_2+...+A_n\cdot B_n. \end{aligned}$$

[0014] Component patterns A_i and B_i suitable for use in the invention should preferably also satisfy the independence criterion set out above, that the resultant pattern that results from the interaction of the display patterns is substantially the composition of the resultant patterns that would have resulted from the interaction of pairs of associated component patterns taken in turn. This may be represented by stating that A_i and B_j do not interact whenever $i \neq j$, where i and j are each any number selected from 1 to n.

[0015] When this criterion criterion is satisfied, the definition of the resultant visible pattern A·B is simplified to

$$A\cdot B = A_1\cdot B_1+A_2\cdot B_2+...+A_n\cdot B_n$$

In such a case the overall resultant display pattern A·B can be regarded as composed of a series of component resultant patterns $A_1 \cdot B_1$, $A_2 \cdot B_2$, $A_3 \cdot B_3$, and so on.

[0016] Advantages of such embodiments of the invention can be seen with reference to the problems encountered by the prior art:

(a) wherein the final resultant pattern A B can be composed of more than one component resultant pattern $A_1 \cdot B_1, A_2 \cdot B_2 .... A_n \cdot B_n$, it can be arranged, by displacement along the direction of motion, that not all the component resultant patterns disappear at the same time, so that continuity of indication is maintained;

(b) although it remains the case that any one component resultant pattern can only be visible in one of N-1 (eg. 11) widely spaced positions, and can never be seen in other positions, the final resultant pattern A B can be composed of n multiple component resultant patterns, $A_1 \cdot B_1 + A_2 . B_2 + ... A_n \cdot B_n$, relatively displaced along the direction of motion in such a way that each of them has a different position where it is visible, so that there are up to n(N-1) positions where at least one component resultant pattern is visible.

[0017] The present invention has particular applica-

tion where N is equal to or greater than 10.

[0018] It is particularly preferred to arrange that the visual effect of viewing a component pattern on the first display pattern interacting with a component pattern associated therewith on the second display pattern is visually more noticeable than the visual effect of viewing a component pattern on the first display pattern interacting with a non-associated component pattern on the second display pattern.

[0019] There will now be set out in general terms three examples of ways in which the first and the second display patterns may be embodied and made to interact:

1. The first display pattern A may be a pattern of regions on a surface that emit, reflect, or transmit light in different ways, while the second pattern B is a pattern of regions on a second surface that emit, reflect, or transmit light in different ways, the second surface being placed so that the first surface can be viewed through it, the patterns on each surface thus interacting to produce a resultant pattern that moves as the two surfaces move relative to one another. For example, where the display pattern B is transparent, the display pattern A is visible and forms the resultant pattern, but where the display pattern B is opaque, it is the display pattern B that forms the resultant pattern. The use of colours and polarised light allows resultant patterns whose appearance depends on both patterns A and B.

2. One pattern may be a pattern of regions on a surface that emit, reflect, or transmit light in different ways, while the other pattern is a pattern of light projected onto that surface and viewed either by reflection or by transmission. Either of the two patterns may be stationary while the other moves.

3. The first pattern A may be a pattern of light projected onto a reflective or translucent surface, while the second pattern B is another pattern of light projected onto the same surface. For example, wherever A is white, it will mask the appearance of B; wherever B is white, it will mask the appearance of A; and where neither A nor B is white, the resultant appearance will depend on the colours of both A and B.

[0020] There will now be set out three examples of ways in which component patterns suitable for use in the invention may be produced:

1. Spatial separation. It may be arranged that component patterns which are not associated with each other differ by virtue of being spatially separated in a direction perpendicular to the said relative movement between the display patterns. In this case display pattern A may be divided into areas by notional lines along the direction of relative motion, and each area is assigned to a different component pattern A_i. Pattern B is divided into corresponding areas, and each area is similarly assigned to a different B_i. In the case of rectilinear motion, these areas are thin strips; in the case of circular motion, the areas are annular. This arrangement ensures that the areas will remain separate even when the display patterns are in motion, and the independence criterion set out above is satisfied because each component pattern is confined to a distinct area and cannot interact with components in other areas. The maximum value of n is determined by manufacturing tolerances. Each feature of a component pattern may be relatively small, being confined to a small region; but a clear indication is nevertheless obtained because of the capacity of the human visual system to interpret interrupted lines (e.g. dotted lines) as lines, and adjacent interrupted lines as a single, thicker line.

2. Colour separation. It may be arranged that component patterns which are not associated with each other differ by virtue of emitting, transmitting or reflecting light of different frequencies. In this case component patterns A_1, A_2,... A_n may exist in the same space, but each of them emits, reflects, or transmits light of a different colour, and each component pattern B_i only transmits light from the corresponding associated component pattern A_i, thus satisfying the independence criterion set out above. The maximum value of n is determined by the narrowness of the wavelength band within which an individual component pattern A_i can be made to emit, reflect, or transmit and within which an individual component pattern B_i can be made to transmit. In practice, the case n=2, with A_1 and A_2 being complementary colours, will be the simplest to manufacture. It should be noted that in a practical situation it is sufficient for the orthogonality criterion to be satisfied approximately, as long as the parasitic patterns (for example, $A_1 \cdot B_2$ and $A_2 \cdot B_1$) are insignificant enough not to distract the eye from the intended resultant pattern.

3. Polarisation. It may be arranged that component patterns which are not associated with each other differ by virtue of emitting, transmitting or reflecting light of different polarisation. In this case component pattern A_1 emits, reflects, or transmits light of a given polarisation, and component pattern B_1 only transmits light of that same polarisation; component pattern A_2 emits, reflects, or transmits light polarised in a perpendicular direction, and component pattern B_2 only transmits light of that same polarisation. The polarisations are arranged so that their relative orientation is unchanged by the relative motion of the patterns. If the relative motion is linear, this criterion is automatically met by any arrange-

ment of mutually perpendicular linear polarisations; if the relative motion is circular, then the polarisation of A_1 and B_1 at any given point could be arranged to be parallel to the radius vector at that point, while the polarisation of A_2 and B_2 could be arranged to be perpendicular to that vector. If (as is usually the case) A_i and B_i were transparent only in fairly narrow strips, this state of affairs could be adequately approximated by using appropriately aligned pieces of linear polarising material, since in narrow sectors of a circle the direction of the radius vector varies only by a small amount. Any deviation from perpendicularity or inadequacy in polarisation would lead to the independence criterion being satisfied only approximately, and to parasitic patterns $A_1 \cdot B_2$ and $A_2 \cdot B_1$ in the resultant pattern, which would be acceptable as long as they were insignificant enough not to distract the eye from the intended resultant pattern $A_1 \cdot B_1 + A_2 \cdot B_2$. It should be noted that this method of constructing suitable component patterns is only practicable if the main interaction "·" by which the patterns A and B interact is subtractive (eg. selective transmission or reflection by a surface): if the interaction is additive (eg. when both A and B are patterns projected together onto a single surface) then this method would not apply because the projection onto a surface of light of two different polarisations has no distinctive effect.

[0021] The above three methods, as well as others (eg. moiré effects) that may satisfy the independence criterion exactly or approximately, may be combined to increase the number of components available. For example, display patterns A and B can be separated spatially into n components, each of which is further subdivided into 2 complementary colours, which would give a total of 2n distinct component patterns.

[0022] It should be noted that in the case of spatial separation it is possible for many of the component patterns A_i to be similar to each other (and likewise with the component patterns B_i). For example, one possible arrangement would have A_1, A_3, A_5,... all having features that repeat the same number of times and start at the same point, while A_2, A_4, A_6,... are displaced from A_1, A_3, A_5,... by a certain distance (the same for each of them) along the direction of relative motion. The effect would be of two interrupted lines at different positions.

[0023] In certain cases, it is meaningful to speak of the number n of patterns tending to infinity. For example, using rotary motion, one might place each component pattern A_i or B_i at a distance (ir/n) from the centre, where r is the radius of the disc, and displace each of them by an angle ($i\theta/n$) relative to a given reference, where θ is an arbitrary, fixed angle. For small n, this gives a combination of discrete patterns, as previously discussed; as $n \rightarrow \infty$, it becomes a smooth spiral. This kind of operation can be done whenever some property of A_i or B_i (colour, displacement, width,...) is a continuous function of (i/n).

[0024] The invention finds particular application where the said relative movement between the first and second display patterns is a rotary movement. Preferably the various said regions of the display patterns recur around circular paths concentric with the axis of rotary relative motion between the first and second display patterns. The first and second display patterns may take various forms in order to produce the rotary movement, for example the first and second patterns may lie on coaxial cylinders positioned one inside the other. However it is much preferred that the pattern on each of the first and second display patterns lies in a surface substantially perpendicular to the axis of rotation of relative movement, for example as provided by a pair of discs positioned in register with each other.

[0025] It will be appreciated that the invention may provide many forms of display device for transmitting information to the observer, such as a watch in which the said moving resultant pattern indicates the passage of time. However other forms of display device may utilise the invention without conveying information, for example to give decorative moving patterns which may be used for example on jewellery, or to provide an attractive backdrop for entertainment such as dance, or to be combined with conventional hands on a watch so as to provide a decorative feature on a watch.

[0026] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a front view of a rotary display device which may incorporate the invention, and Figure 1a is a diagrammatic side view of the device of Figure 1;

Figures 2a, 2b and 2c show respectively: a front view of a pattern of light producing regions which may be provided on the stator of the display device shown in Figures 1 and 1a; a pattern of light producing regions which may be provided on a rotor 14 of the display device shown in Figures 1 and 1a; and a resultant pattern which is observed by viewing the stator 13 through the rotor 14 during rotation of the rotor relative to the stator; these views showing a known display device;

Figures 3a, 3b, 3c and 3d show the same views in the same sequence, Figure 3d showing a further view of the resultant pattern; these views showing a further known display device;

Figures 4a, 4b, 4c and 4d show the same views in the same sequence; these views showing a display device embodying the invention;

Figures 5a, 5b, 5c and 5d show the same views in the same sequence; these views showing a further

display device embodying the invention; and there being provided additional views (in negative for clarity) in Figures 5aa and 5bb showing enlargements of parts of the views of Figures 5a and 5b;

Figures 6a, 6b and 6c show the same views as Figures 5a, 5b and 5c, in the same sequence, but in respect of a further display device embodying the invention;

Figures 7a and 7b show respectively: a pattern of light producing regions which may be provided on a stator; and one of the resultant patterns which would observed by viewing the stator through a related rotor during rotation of the rotor relative to the stator; these views showing a further display device embodying the invention;

Figures 8a and 8b show the same views in the same sequence; these views showing a further display device embodying the invention; and

Figures 9a and 9b show the same views in the same sequence; these views showing a further display device embodying the invention.

[0027] Figure 1 shows in front view a display device 11 which may embody the present invention, and Figure 1a shows a diagrammatic side view of the display device. Mounted on a base 12 is a stationary disc forming a stator 13 and a rotary disc forming a rotor 14. The rotor 14 is mounted on a shaft 15 passing through the centre of the stator 13, and driven by a motor 16 mounted on the base 12. The stator 13 bears a first display pattern of light producing regions for producing light by generation, reflection or transmission at the region, and the rotor 14 bears a second display pattern of transmitting regions for transmitting light from the light producing regions of the first element.

[0028] In Figures 2a and 2b there are shown respectively known forms of pattern which may be provided on the stator 13, and on the rotor 14. Figure 2c shows a resultant pattern when the stator 13 is viewed through the rotor 14. When the rotor 14 is rotated, the resultant pattern shown in Figure 2c rotates about the axis of rotation of the rotor 14. Considering the known patterns in detail, the stator 13 has a first display pattern 19 of eleven light producing regions 17 for producing light by generation, reflection or transmission at the region. The light producing regions 17, for example being white painted sectors of the disc, alternate around the axis of rotation with darker regions 17' which may for example be black painted sectors of the disc. Similarly, on the rotor 14, there may be provided twelve transparent regions 18, which alternate around the disc 14 with opaque regions 18'. By way of example, the light transmitting regions may be transparent plastics material, or may be apertures cut in an opaque disc. As shown, the light transmitting regions 18 and the non or lesser transmitting regions 18' may be sectors of the disc, alternating around the disc. The view in Figure 2c shows a resultant pattern 21 which, when the rotor 14 is rotated, rotates about the axis of the discs in the same direction as the rotor but at a speed twelve times faster than the rotor. It is clear that if in this known device the resultant pattern 21 were to be used a hand of a clock, the resulting hand would not be sufficiently sharply localised.

[0029] To attempt to correct this, the patterns can be modified so as to make the black sectors 17' on the stator, and the opaque sectors 18' on the rotor, to be angularly wider than the white sectors 17 and the light transmitting sectors 18. This arrangement is shown in Figures 3a and 3b and the resultant pattern 21 is shown in Figures 3c and 3d, at different instants of time. This gives rise to a narrower resultant pattern, and this arrangement is known in the prior art specification GB 2206712. Although this arrangement gives a more clearly defined resultant pattern 21, another problem arises, which is that the resultant pattern 21 appears as a single clearly defined clock hand at one of only eleven distinct positions around the dial. The widths of the light producing and transmitting regions have been chosen, as in the prior art DE-3503672-A1, to be 30/11 = 2.73 degrees, ensuring that it is possible to have a single resultant pattern as shown in Figure 3c. Nevertheless, it can be seen in Figure 3d that at certain points in the motion, the resultant pattern bifurcates into two pieces 30 degrees apart, so that assessing its position requires visual interpolation. Moreover, referring to Figure 3a, it can be seen that a resultant bright pattern can never appear in positions where the stator is dark, so that the resultant pattern can only appear in 11 widely separated places, and its motion is discontinuous from one such place to the next. It is one object of the invention to provide a more clearly defined resultant pattern 21, suitable for use in a watch or clock.

[0030] Figures 4a to 4d show a first embodiment of the invention. Figure 4a shows a stator 13 having a first display pattern 19 of light producing regions 22 and 23 comprising narrow sectors of light producing painted surface, alternating with black sectors 24. Eleven sectors 22 are painted in a first colour, for example magenta, and eleven interleaved sectors 23 are painted in a complementary colour, for example green. Each coloured section 22 constitutes a first feature which recurs regularly around the stator, providing a first component pattern 25 around the stator 13. Similarly each green sector 23 constitutes a further feature which recurs regularly around the disc to provide a second component battery 26 having the same rate of repetition as the first component pattern 25.

[0031] The rotor 14 has a second display pattern 20 of light transmitting regions 27 and 28. The rotor 14 has twelve sectors 27 of transparent material which is transparent to light of magenta colour and twelve sectors 28 of transparent material which is transparent to light of

green colour, the colours and materials being chosen so that the transparent magenta sectors are as nearly as possible opaque to green light and the transparent green sectors are as nearly as possible opaque to magenta light. The sectors of light transmitting material 27 and 28 are interleaved with one another around the disc, and alternate with sectors of opaque material 29. Each magenta sector 27 constitutes a feature which recurs regularly around the disc to provide a first component pattern 30 and each green sector 28 of transparent material constitutes a feature which recurs regularly around the disc to provide a second component pattern 31. When the rotor 14 is rotated and the stator 13 is viewed through the moving rotor 14, there is observed (as shown in Figure 4c and 4d) a moving resultant pattern 21 which rotates at twelve times the speed of the rotor 14.

[0032] The effect of the two complementary colours which are used is that the first component pattern 30 on the rotor 14 is associated with the first component pattern 25 on the stator 13, and the second component pattern 31 on the rotor 14 is associated with the second component pattern 31 on the stator 14. The frequencies of production of light and of transmission of light, are such that the visual effect of viewing the sectors 22 of the first component pattern through the sectors 27 of the first component pattern 30 is a bright visual effect. The visual effect of viewing the sectors 23 of the second component pattern 26 on the stator 13 through the sectors 27 of the first component pattern 30 on the rotor 14 is a different effect, in this case substantial blackness.

[0033] The widths of the light producing and transmitting regions have now been chosen to be 30/22 = 1.36 degrees, ensuring that it is possible to have a single resultant pattern as shown in Figure 4c. When the resultant pattern bifurcates, as shown in Figure 4d, the two pieces are now 15 degrees apart, considerably increasing the accuracy of indication; moreover, the contrasting colours make visual interpolation easier. In addition, comparing Figure 4a with Figure 3a, it can be seen that there are now 22 places where a resultant bright pattern can appear, making the resultant pattern's motion appear more continuous.

[0034] In another embodiment of the invention, not illustrated, polarised light is used. Light of one polarisation corresponds to the magenta light in Figure 4, and light of a perpendicular polarisation corresponds to the green light. It is preferred, in this case, for the stator to have transparent polarising regions and to be illuminated from behind; but the design and behaviour of the invention are otherwise in every way identical to the coloured version described. It is convenient to choose the directions of polarisation as radial and tangential. Because the transparent regions are narrow, a good approximation to this can be achieved by affixing pieces of linearly polarising material, appropriately aligned, to cover each individual transparent region. It will be appreciated that the polarisation need not be exactly radially and tangentially polarised, but that other mutually perpendicular orientations can be used with advantage in the invention.

[0035] In another embodiment, not illustrated, more than two colours are used, the requirement being that the filters used to pass light of one colour should be opaque to light of all other colours. If three rather than two colours are used, this leads to bifurcations of only 10 degrees, and to 33 places where a resultant bright pattern can appear.

[0036] In other embodiments of the invention, not illustrated, colours and polarisation are combined. For instance, denoting the two directions of polarisation by R (radial) and T (tangential), and the two available colours of light as O (orange) and B (blue), four different kinds of filters can be used: OR, OT, BR, and BT. Each of these filters will only pass light from the same filter: for example, considering OR, OR cannot pass light passed by OT because the directions of polarisation are different, cannot pass light passed by BR because the colours are complementary, and cannot pass light passed by BT for both reasons. Thus, in general, the number of available kinds of filters is twice the number of colours. Using three colour filters, this would lead to bifurcations of only 5 degrees, finer than the minute gradations on a clock dial.

[0037] In other embodiments, not illustrated, the sets component patterns on the rotor 14 may have different transmission characteristics by virtue of transmitting light through rulings of different kinds giving rise to different Moiré effects. Thus effects analogous to the polarised light referred to above can be obtained by using rulings of different kinds on the rotor and stator. Experimentation is required to find the kinds of pattern that look most distinctive when associated component patterns on the rotor and stator interact, while looking as insignificant as possible when non associated component patterns on the rotor and stator interact.

[0038] Figures 5a to 5d show a second embodiment of the invention. Figures 5a and 5aa show a stator 13 having a first display pattern 19 of light producing regions 32-1, 32-2, ... and 33-1, 33-2 (referred to generically as regions 32 and 33) comprising radially spaced, part annular regions of decreasing radius aligned along radii of the axis. The part annular regions 32, 33 are conveniently formed by light producing painted surfaces for example white, contrasting with the remainder 34 of the stator 13 which is painted black. The rotor 14 of Figures 5b and 5bb has a corresponding pattern, namely a second display pattern 20 of light transmitting regions 37-1, 37-2 .... and 38-1, 38-2 comprising part annular regions of decreasing radius aligned along radii of the axis. The part annular regions 37 and 38 are conveniently formed by transparent material contrasting with the remainder 39 of the rotor 14 which is opaque.

[0039] Referring to Figures 5a and 5aa, the first display pattern 19 is composed of forty two annular component patterns 35-1 to 35-42 and 36-1 to 36-42. Each

component pattern e.g. 35-1 is composed of eleven light producing regions e.g. 32-1 to 32-11. In Figures 5b and 5bb, the second display pattern 20 is composed of forty two annular component patterns 40-1 to 40-21 and 41-1 to 41-21. Each component pattern, e.g. 40-1, is composed of eleven light transmitting regions e.g. 37-1 to 37-11. Each of the light producing and light transmitting regions is 1.36° wide, equally spaced around the stator or rotor. The individual annular component patterns are aligned in such a way that half of them have one given orientation and the other half are displaced from the first half by 360/22 = 16.36 degrees on the stator and 360/24 = 15 degrees on the rotor. Conceptually, this may be achieved by numbering the annular components along a radius, aligning the even-numbered components in one direction, and the odd-numbered components in an appropriately displaced direction.

[0040] Figures 5c and 5d show two possible resultant patterns when the stator is viewed through the rotor. The widths of the light producing and transmitting regions are exactly the same as in Figure 4, and the bifurcation behaviour and the improvement in the precision of reading are also identical.

[0041] Considering the representations of the resultant pattern 21 in Figures 5c and 5d, the progress of time can be watched in the gradual appearance and thickening of the leading part of the resultant pattern 21 and the thinning and disappearance of the trailing part of the resultant pattern 21. In Figure 5d, the illustration is shown as a negative of the illustration in Figure 5c, so as to make the resultant pattern clearer.

[0042] Further useful effects can be achieved by variations in the overall shape of first and second display patterns, for example as shown in Figures 6a to 6c. Components in Figures 6a to 6c which correspond to components in Figures 5a to 5d are indicated by like reference numerals or like numerals primed. For example the rotor 13 and stator 14 are identical to those in Figures 5a to 5d, except that the component patterns 35', 36', 37' and 38', are composed of part annular regions 32', 33', 37' and 38' which have a constant linear width throughout the radial direction, instead of the constant angular width shown in Figures 5a and 5b. The consequence of this is an altered resultant pattern 21 shown in Figure 6c, compared with the resultant pattern 21 shown in Figures 5c and 5d. The resultant pattern 21 in Figure 5c is distinctive in that it gives rise to a single central radial marker at all positions.

[0043] As was discussed with reference to Figures 2a to 2c and 3a to 3d, it is necessary to narrow the lighter parts of the rotor and stator because a 50:50 duty cycle leads to a resultant pattern that is too broad and vague. The narrower the light parts, the narrower the resultant "hand" of the clock is, and the less spread out in space it becomes, until at the extreme it appears only briefly and disappears before the next "hand" has started to appear. In the examples shown in Figures 3c and 3d, and 4c and 4d, the thickness of the resultant is chosen to give a reasonable visual compromise. For simplicity of exposition in the above descriptions, the features of each annular component have been shown with the same angular size irrespective of the component's distance from the centre.

[0044] In Figures 6a to 6c where the regions have a constant linear thickness, a region varies in angular thickness with the distance from the centre. Near the centre, such regions are so wide as to overlap; as the region considered moves further out, the regions attain a 50:50 duty cycle. Further radially outwards the lower duty cycle which is illustrated in previous figures (giving fewer and more localised features) is produced, until near the edge of the disc the result pattern is so narrow that the "hand" only becomes visible at the precise moment that it passes over one of the eleven, or twenty two, available positions. The visual effect is of each branch of the pattern in turn growing, reaching a maximum extension, and then shrinking again as the next branch grows.

[0045] There is great scope of adjusting this type of configuration, with non constant angular widths, to suit the aesthetic and practical criteria involved. Figures 6a to 6c show just one example. In Figure 6c, it should be noted that each marker has its "perfect" time when it will reach its full length. This is the time at which a conventional minute hand would be precisely over a time marking. Since the central marker shown in Figure 6c grows as its perfect time approaches and shrinks afterwards, the length of a marker is an accurate indication of the time left to the perfect time. A simple graticule of circles drawn on the rotor can be used to calibrate this method. When a marker touches the "one minute" circle this means it is one minute away from its perfect time. When it touches the "thirty second" circle it is thirty seconds away.

[0046] Finally there are shown in Figures 7a to 9b a series of further patterns which can be obtained using the effects of the invention. In each case, only the stator and a sample resultant pattern are shown, and in every case the rotor resembles the stator but has 12-fold rather than 11-fold symmetry. These patterns will not each be described in great detail since they are in every respect similar to the patterns shown in Figures 5 to 5d, except that the relative angular displacements of the annular components are varied systematically (Figures 7 and 8) or pseudo-randomly (Figure 9).

[0047] By way of example, Figure 7a shows a pattern which may be applied to the stator 13, with a corresponding pattern on the rotor 14 but with a different repetition rate of recurring features in the pattern, and Figure 7b shows a resultant pattern obtained by viewing the stator of Figure 7a through the rotor as described, while the rotor is rotating relative to the stator. The pattern shown in Figure 7a is a spiral pattern. The spirals are made up of light producing regions which repeat around a series of annuli of increasing radius, the light producing regions in each circle being offset by the

same amount from the previous circle, so as to give the display of a spiral. Considering each of the annuli in turn, each contains a recurring feature which recurs around the annulus. The pattern on the rotor is made up in the same way except that the repetition rate is different. The result is the resultant pattern 21E shown in Figure 7b.

[0048] A similar pattern in Figure 8a appears on the stator, and again consists of a series of annuli each containing a repeating feature. Again the rotor is made up with the same pattern, but with a different rate of repetition. The pattern shown in Figure 9a appears to be a random pattern, but in fact consists of a series of annuli of increasing radius, each of which has a feature which repeats around the rotor, the rate of repetition being the same for each annulus. The pattern on the rotor is made up in the same way except that the repeating features repeat at a different rate of repetition. Figure 9b shows the resultant pattern, which rotates around the display device when the stator is viewed through the rotating rotor.

[0049] The description given has concentrated on the arrangements for a minute hand, because this is most problematic, the low gearing ratio restricting the number of positions in which the hand can be seen. The hour hand presents no problem, since it can simply be painted onto the rotor. It should be noted however that, by definition, the hour hand has to be different from the other appearances on the rotor. If the rotor is alternately black and transparent, then the hour hand will have to be white or coloured. If the rotor is white and transparent (an arrangement that has not be illustrated but which works very well), the hour hand will have to be dark. If the rotor is metal pierced to reveal the stator beneath, the hour hand can be engraved onto the rotor.

[0050] The second hand presents fewer theoretical problems, but demands very accurate manufacture, since it depends on the interaction of 720 stripes of light and dark. The second hand cannot of course occupy the same space on the rotor as the minute hand, but it can make a very effective indicator if confined to the periphery of the rotor.

[0051] The above description has concentrated on cases where the ratio of rotor to stator is n:n - 1. Further interesting effects can be obtained with a ratio of features on the rotor to those on the stator is given by 2n: 2n - 2, 3n:2n - 3, which produces patterns that rotate at the same speed as n:n - 1 but with more hands apparent. The potential exists for appropriate combinations of these to generate almost any desired brightness profile in the resultant pattern, just a square wave can be synthesised from an appropriate combination of sine waves.

Claims

1. A display device comprising:

display means (13, 14) for displaying a first display pattern (19) in combination with a second display pattern (20); and

means (16) for producing relative movement between the first and second display patterns (19, 20);

the first and second display patterns (19, 20) each having features (22, 27; 32-1, 37-1) which recur regularly along the direction of relative movement between the two display patterns at repetition rates which are different on the two display patterns;

the display patterns (19 and 20) being related in such a manner as to give rise to a moving resultant pattern (21) which is the result of the interaction of the first and second display patterns (19 and 20) during the said relative movement, the resultant pattern (21) moving at a speed greater than the said relative movement between the first and second display patterns (19 and 20);

characterised in that

each display pattern (19, 20) is composed of more than one component pattern (25, 26, 30, 31; 35-1, 36-1, 40-1, 41-1);

each component pattern having a feature (22, 23, 27, 28; 32-1, 33-1, 37-1, 38-1) which recurs regularly along the direction of relative motion between the display patterns (19 and 20);

one of the component patterns (25; 35-1) on the first display pattern (19) being associated with one of the component patterns (26; 40-1) on the second display pattern (20), and another of the component patterns (26; 36-1) on the first display pattern (19) being associated with another of the component patterns (31; 41-1) on the second pattern (20), in such a manner that the visual effect of viewing in combination two associated component patterns (25, 30; 35-1, 40-1) is different from the visual effect of viewing in combination two non-associated component patterns (25, 31; 35-1, 41-1); and

it being arranged that for each pair of associated component patterns (25, 30 and 26, 31; 35-1, 40-1, and 36-1, 41-1), the repetition rate for a component pattern of the first pattern (19) is different from the repetition rate for an associated component pattern of the second pattern (20).

2. A display device according to Claim 1 in which

   the composition of each of the display patterns (19, 20) from its component patterns is such that at every location of the display pattern, the pattern emits, reflects or transmits substantially whatever light would be emitted, reflected, or transmitted at that location by any of the component patterns on its own; and

   the component patterns are such that the resultant pattern that results from the interaction of the display patterns is substantially the composition of the resultant patterns that would have resulted from the interaction of pairs of associated component patterns taken in turn.

3. A display device according to Claim 1 or 2 in which component patterns (25 and 31, 26 and 30) which are not associated with each other differ by virtue of emitting, transmitting or reflecting light of different frequencies.

4. A display device according to Claim 3 in which component patterns (25 and 31, 26 and 30) which are not associated with each other differ by virtue of emitting, transmitting or reflecting light of complementary colours.

5. A display device according to any preceding claim, in which component patterns (35-1 and 41-1, 36-1 and 40-1) which are not associated with each other differ by virtue of being spatially separated in a direction perpendicular to the said relative movement between the display patterns.

6. A display device according to Claim 5 in which the said recurring features (32-1, 33-1) of component patterns (19) on the same display pattern recur at the same repetition rates but are displaced relative to each other in the direction of relative movement between the display patterns.

7. A display device according to any preceding claim, in which component patterns which are not associated with each other differ by virtue of emitting, transmitting or reflecting light of different polarisation.

8. A display device according to any preceding claim in which the first display pattern (19) comprises a pattern of light producing regions on a first patterned element and the second display pattern (20) comprises a pattern of light transmitting regions on a second patterned element (14) overlying the first patterned element, the said resultant pattern being produced by viewing the first patterned element through the second patterned element.

9. A display device according to Claim 8 in which the transmitting regions of a component pattern of the second display pattern (20) transmit light to a greater extent from the light producing regions of an associated component pattern of the first display pattern (19) than from a non-associated component pattern.

10. A display device according to any of Claims 1 to 8 in which the visual effect of viewing an interaction of a pair of associated component patterns is visually more noticeable than the visual effect of viewing an interaction of a pair of non-associated component patterns.

11. A display device according any preceding claim in which the said relative movement between the first and second patterns (19, 20) is a rotary movement.

12. A display device according to Claim 11 in which the said features (22, 23, 27, 28; 32-1, 33-1, 37-1, 38-1) on each display pattern (19, 20) recur around circular paths concentric with the axis of rotary relative motion between the first and second display patterns.

13. A display device according to any preceding claim in which for a pair of associated component patterns the number of repeating features on the first display pattern (19) is N - 1 and the number of repeating features on the second display pattern (20) is N, where N is a whole number, the arrangement being such that the resultant pattern (21) moves at a speed which is a multiple of N times the relative movement between the display patterns.

14. A display device according to Claim 13 in which N is greater than 10.

15. A display device according to any preceding claim comprising a watch or clock in which the said moving resultant pattern (21) indicates the passage of time.

Fig.1.

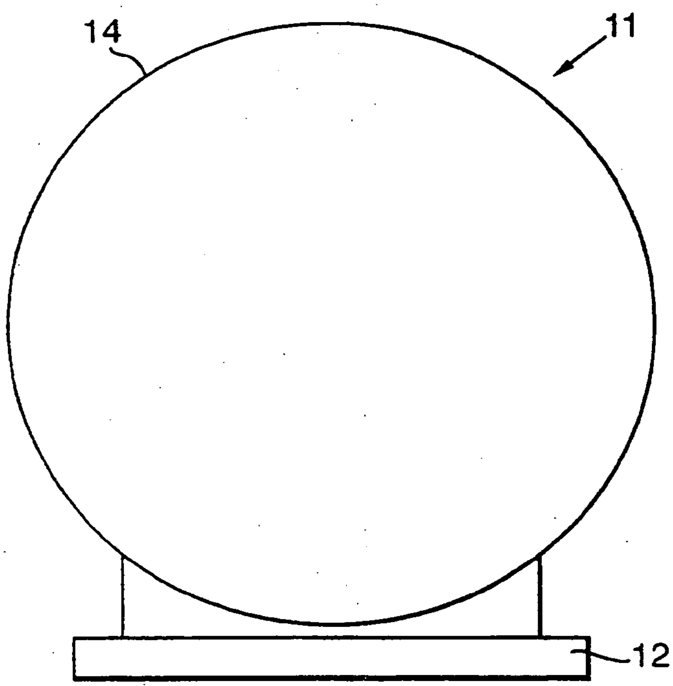
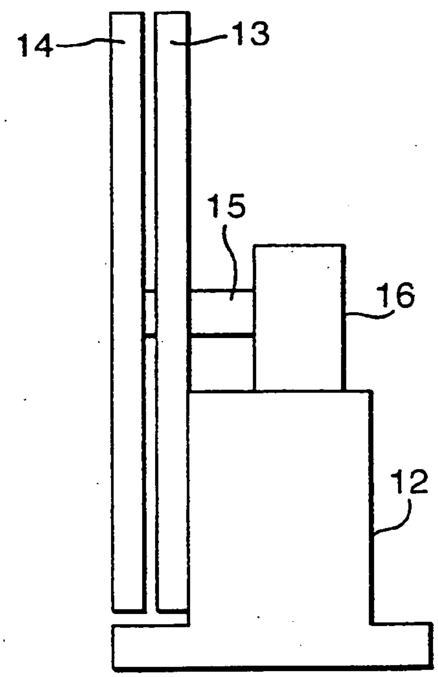


Fig.1a.



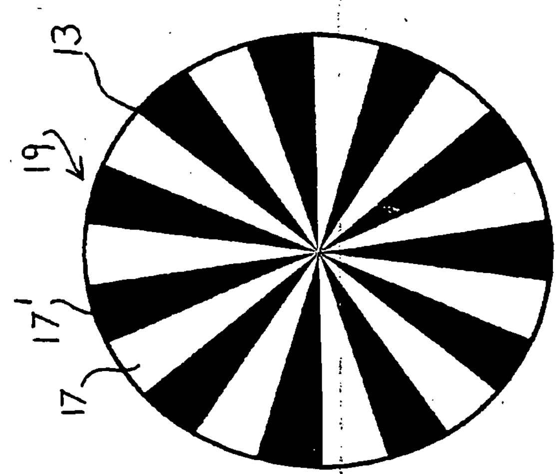


FIG. 2a

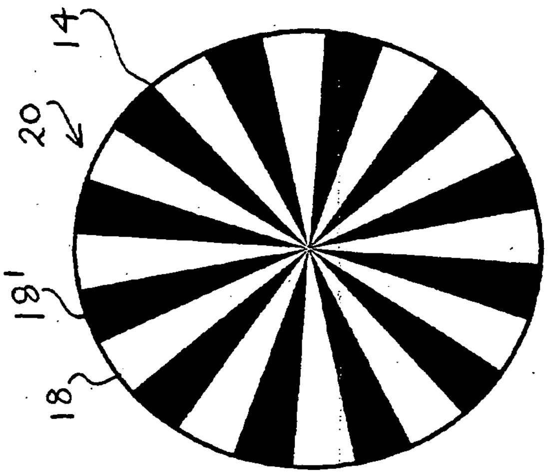


FIG. 2b

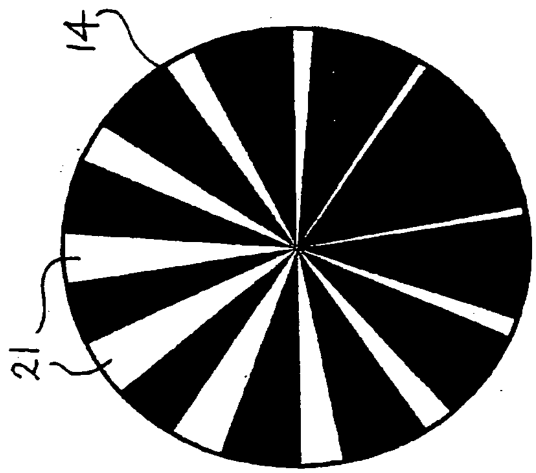


FIG. 2c

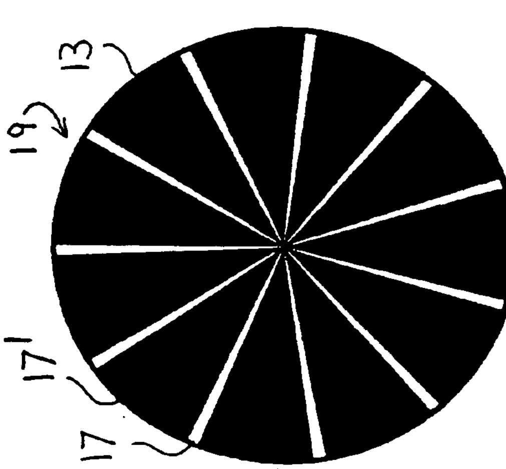


FIG. 3a

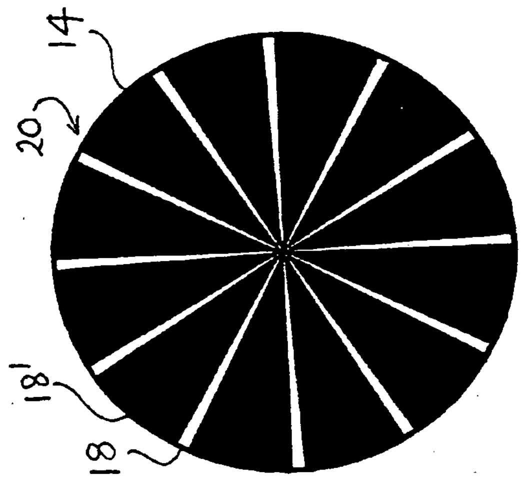


FIG. 3b

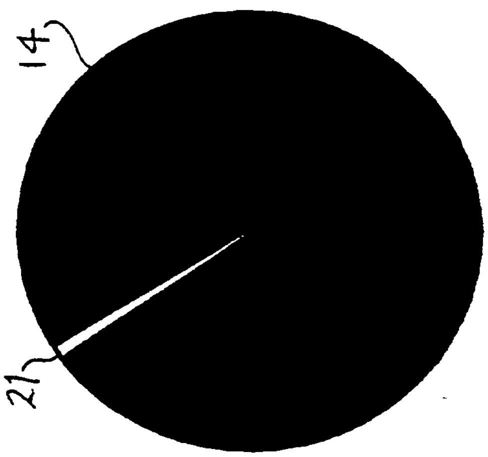


FIG. 3c

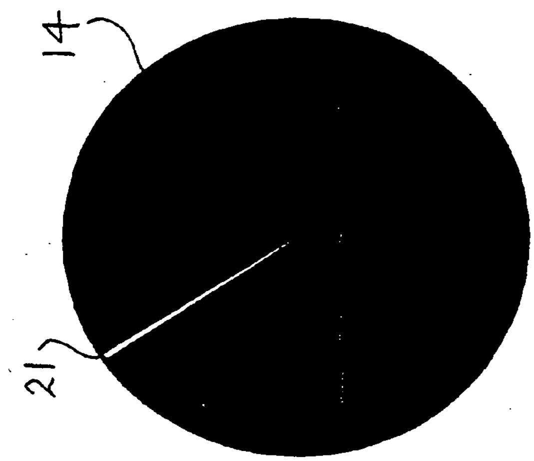


FIG. 4c

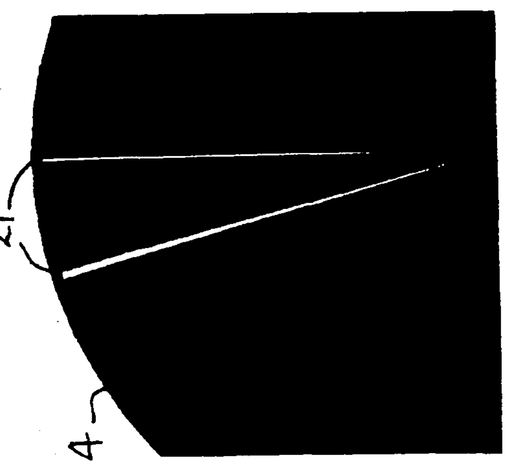


FIG. 4d

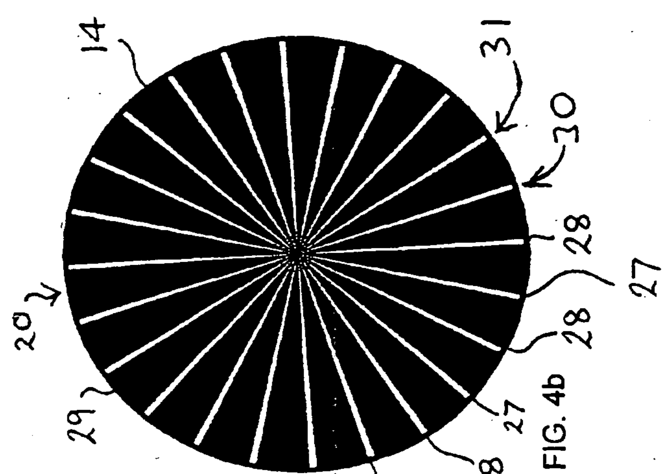


FIG. 4b

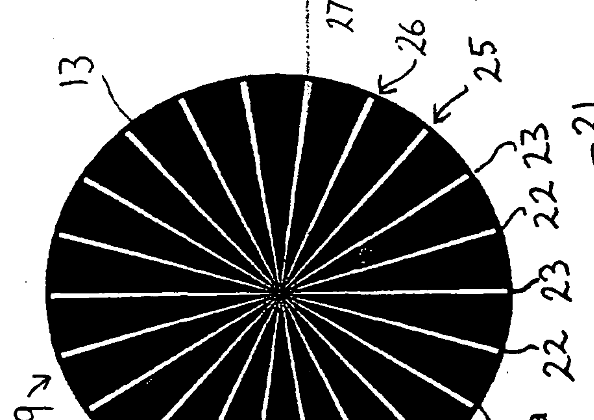


FIG. 4a

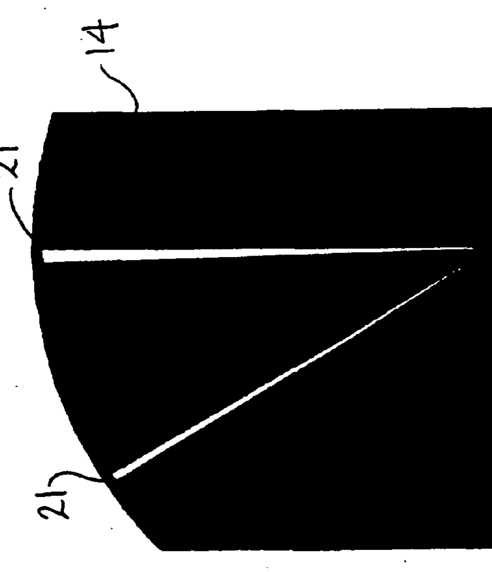


FIG. 3d

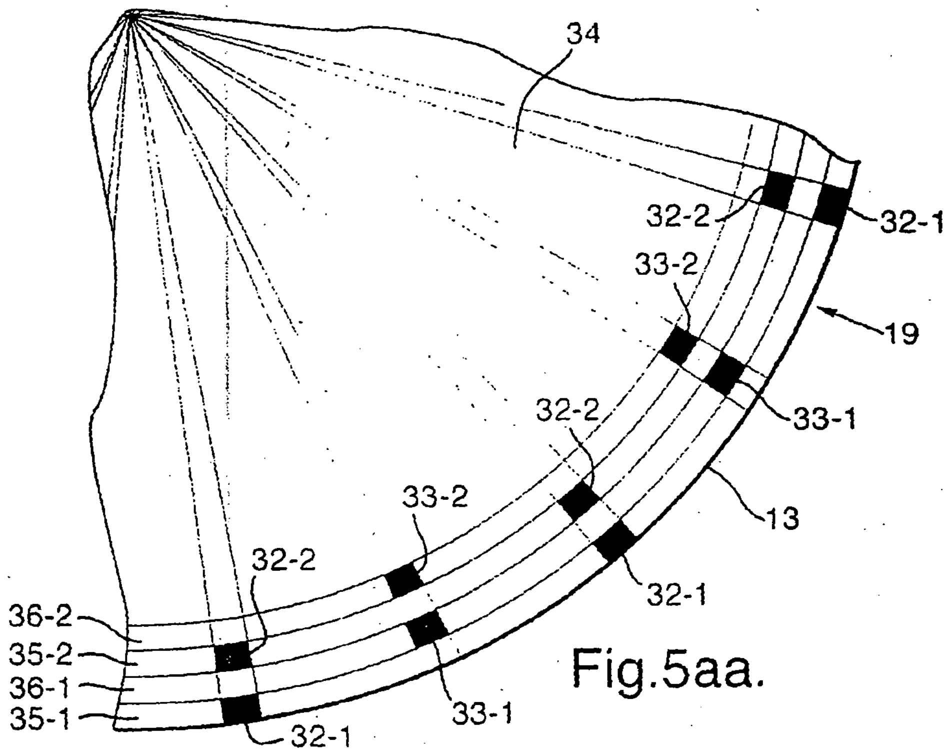


Fig.5aa.

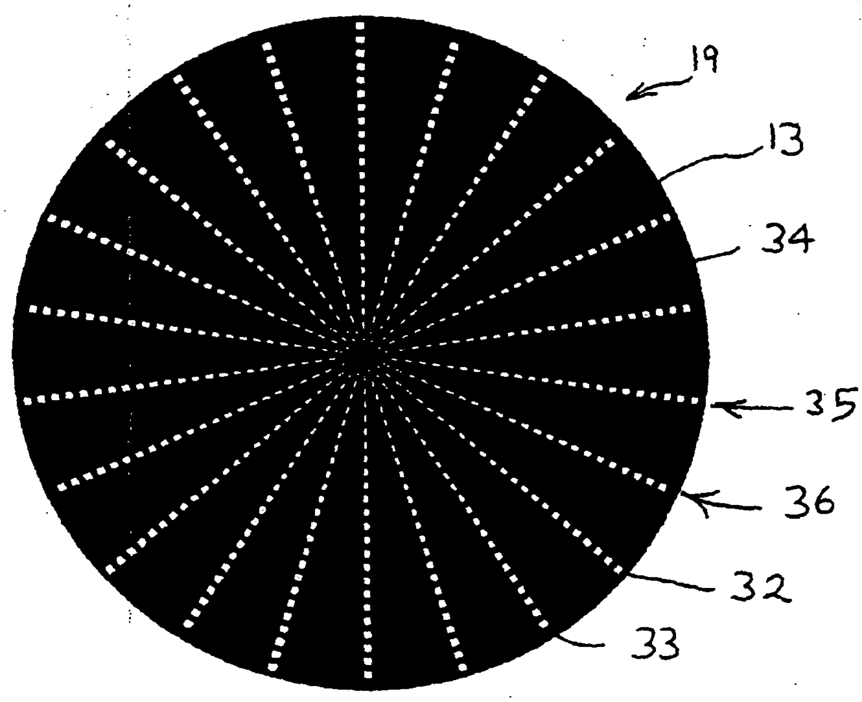


FIG. 5a

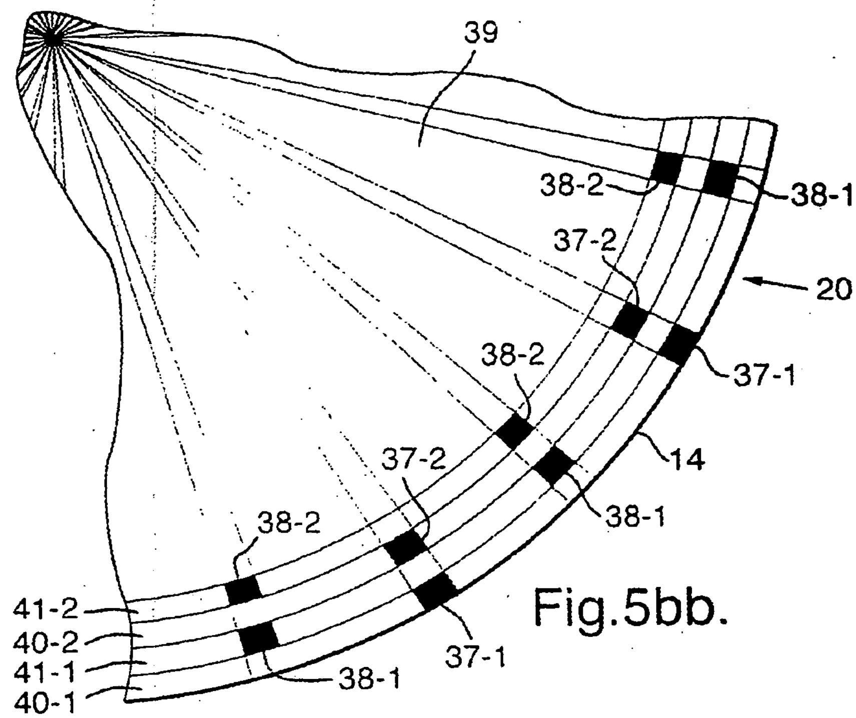


Fig.5bb.

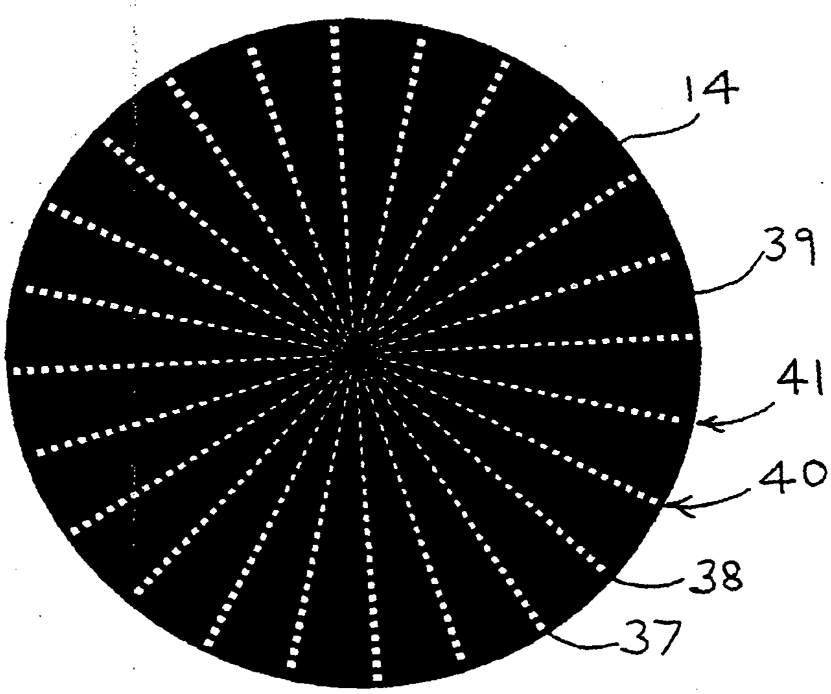


FIG. 5b

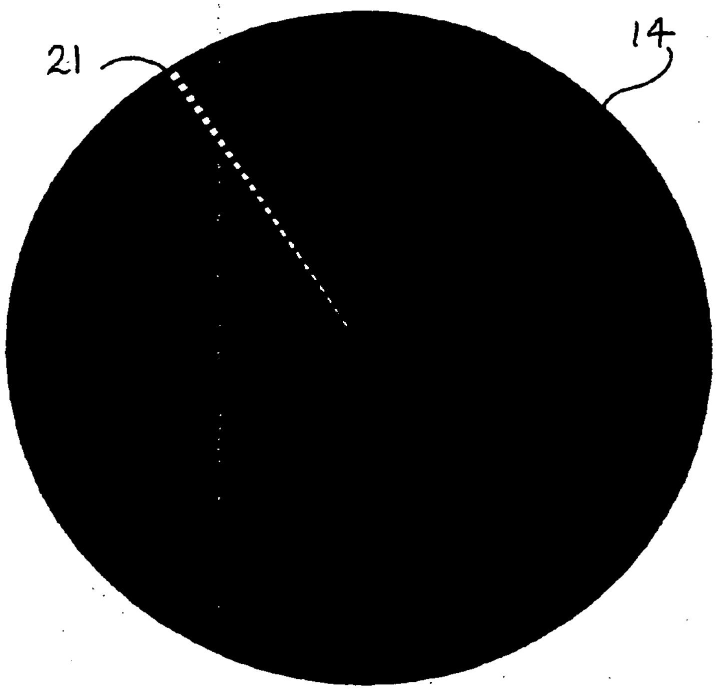


FIG. 5c

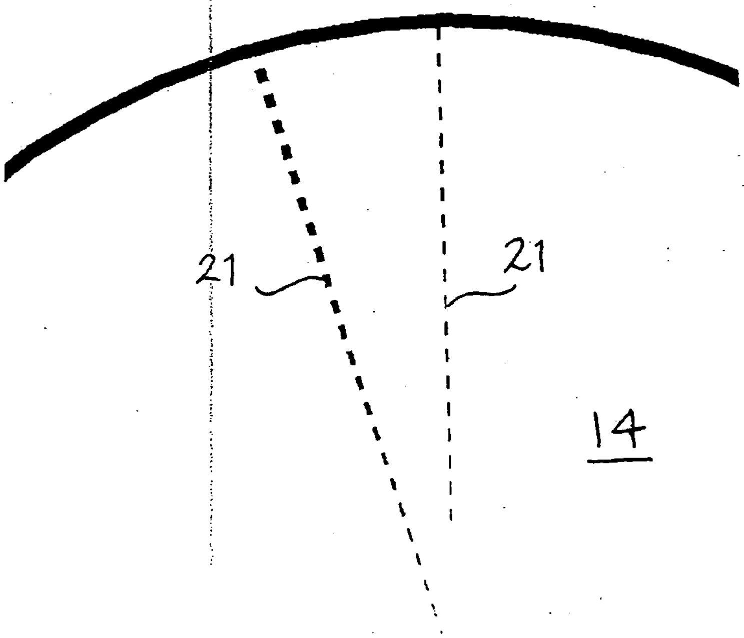


FIG. 5d

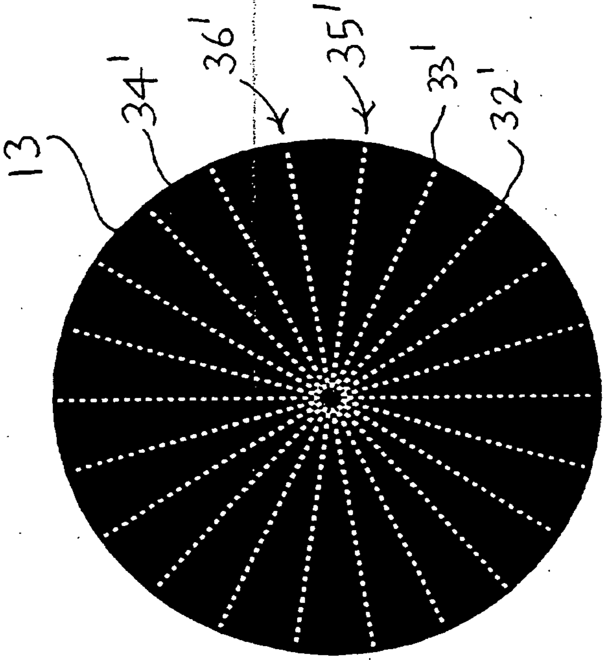


FIG. 6a

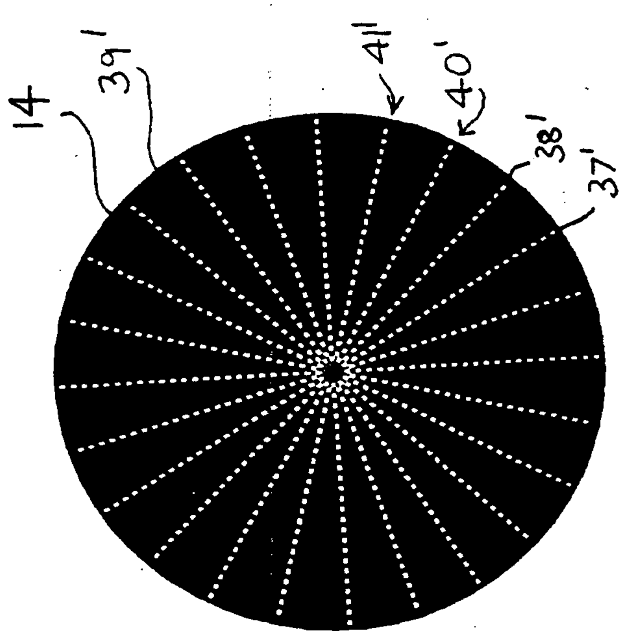


FIG. 6b

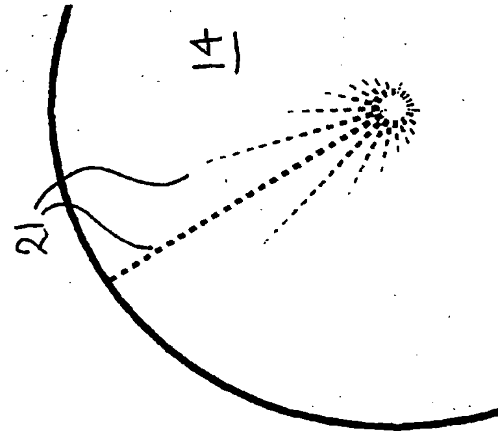


FIG. 6c

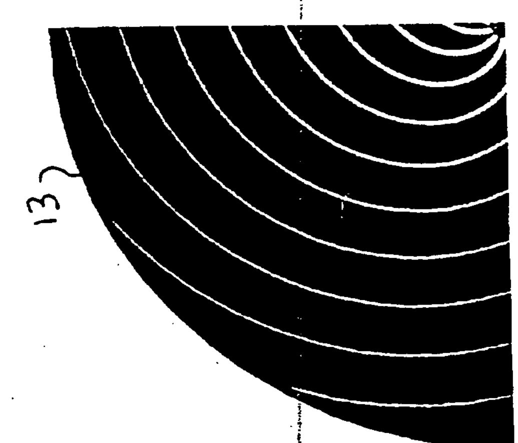


FIG. 7a

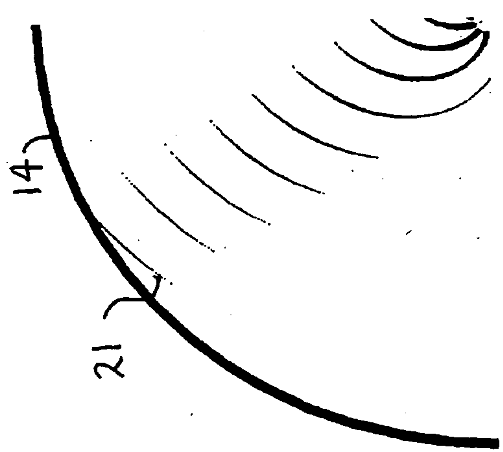


FIG. 7b

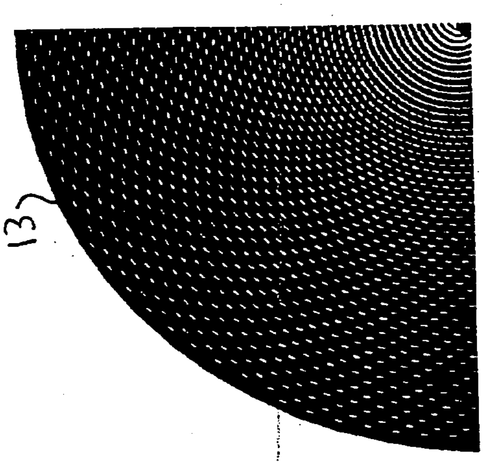


FIG. 8a

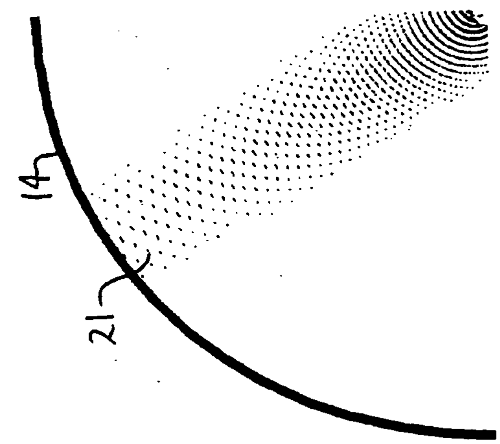


FIG. 8b

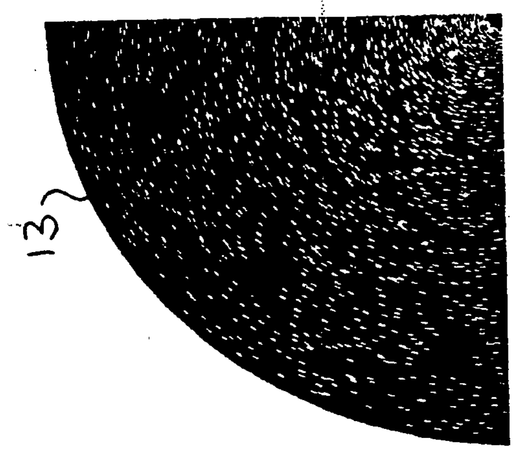


FIG. 9a

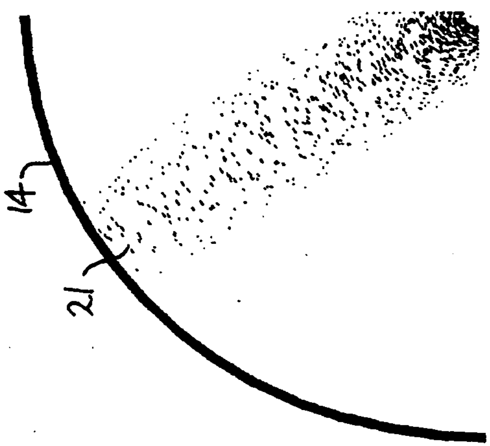


FIG. 9b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 4665

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	GB 2 206 712 A (BURROUGHS ANDREW CHRISTOPHER) 11 January 1989 (1989-01-11) * the whole document * ---	1-14	G04B45/00 G04B19/20 G04B19/08
A	DE 39 18 480 A (NOSCH GUENTER) 14 December 1989 (1989-12-14) * abstract * * figures * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			G04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 October 2001	Lupo, A

CATEGORY OF CITED DOCUMENTS

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05-10-2001

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